Contract Number W9132T-04-C-0017

ReliOn, Inc.

Midpoint Project Report

Proton Exchange Membrane (PEM) Fuel Cell Demonstration
Of Domestically Produced PEM Fuel Cells in Military Facilities

US Army Corps of Engineers
Engineer Research and Development Center
Construction Engineering Research Laboratory
Broad Agency Announcement CERL-BAA-FY03

Telecom PBX Switch
Gabreski Air National Guard Base
Westhampton Beach, New York

March 22, 2005

Executive Summary

The CERL fuel cell installation at Gabreski Air National Guard Base (ANGB), Long Island, New York is one of three ReliOn demonstration sites funded under the BAA-FY03 program (CERL3). The other ReliOn demonstration sites are at Ft. Rucker, Alabama (3 units at 1 kW each and 1 unit at 2 kW) and Ft. Lewis, Washington (4 units at 1 kW each).

This project is testing the reliability of the ReliOn backup power solution for a U.S. military base communication system. The ReliOn 4 kW Fuel Cell System provides backup power to the telephone PBX switch & peripheral equipment located in the communications equipment room in Building 250 at Gabreski ANG. The ReliOn fuel cell supplies power at 48 VDC. The fuel cells are connected to the 48 V battery string on a new uninterruptible power supply (UPS) system installed for this project. The fuel cell systems are configured to monitor the commercial AC power grid as well as the status of the DC batteries on the UPS rack. Upon loss or failure of either power source, the fuel cells will start automatically to provide up to 48 kWh of continuous run power to critical equipment at each site. In addition to providing continuous protection from a primary power failure, the installation is designed to simulate a power failure in the AC grid each day. Data are collected concerning start-up times, power availability, shutdown capability, system efficiencies, load following, and the effects of varying environmental conditions. If the system fails to start up properly or provide required power to the load this is noted in the logs as a failure and counts against the target 90% reliability and availability of the system.

These turn-key packages incorporate ReliOn's air cooled, hydrogen-fueled PEM fuel cells operating in a grid-independent mode. Because ReliOn's fuel cells operate at a relatively low temperature, cogeneration is not a part of this installation. Fuel switching is not required as the I-1000 runs on standard industrial grade hydrogen (99.95% purity), which is readily available. Specific data analyzed consists of: start-up capabilities, availability during outages, shut-down capabilities, system efficiencies, load following, maintenance operations, and effects of environmental conditions.

Key contact personnel at the host site are as follows:

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Table of Contents

1.0 Descriptive Title

A demonstration of modular proton exchange membrane (PEM) fuel cells to serve as back up power for mission critical loads – ILS and other communication systems.

2.0 Name, Address and Related Company Information

ReliOn, Inc.	DUNS #: 137264193
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ReliOn, Inc., a privately held, small business, headquartered in Spokane, Washington, manufactures and markets proton exchange membrane (PEM) fuel cell products based on a unique and patented modular design. The company's current focus is on the sale and installation of highly reliable backup power solutions for critical applications within the telecom, utility and government/military markets.

ReliOn's offering helps customers increase network reliability while reducing overall equipment life-cycle costs in stationary, low power applications, typically requiring 200 watts to 5 kilowatts. ReliOn designs and supplies highly reliable air-cooled, self-hydrating fuel cells that require minimal balance of plant. The ReliOn system is able to bypass potential failure points often present in competing technologies.

ReliOn, formerly Avista Labs, has been developing, demonstrating and marketing PEM fuel cell technology since 1995.

3.0 Production Capability of the Manufacturer

ReliOn, Inc., as described above, is the manufacturer and integrator of the primary products that comprise the backup power solution. These products are the I-1000's, 1kW fuel cell systems, and the Outdoor Enclosure System which is designed to house the fuel cells, hydrogen fuel and fuel delivery system. ReliOn is responsible for installation and commissioning of the backup power solutions and performs all maintenance requirements via company applications engineers.

I-1000 Fuel Cell models and Outdoor Enclosure Systems are commercially available and offered under full warranty terms. ReliOn's contract manufacturer, Celestica, operates out of its facility in Fort Collins, Colorado and currently has the capability to produce 10 fuel cell systems per week, running one shift only. This capacity can easily be expanded as necessary with the addition of back shifts. ReliOn's plan is to produce 500 I-1000 fuel cells and 250 Outdoor Enclosures in 2005. These outputs are expected to double in 2006.

ReliOn's fuel cells are made from common materials using mature manufacturing processes in injection molded plastic, sheet metal fabrication and printed circuit board assembly. The membrane electrode assemblies (MEA) are purchased through a supply agreement with 3M.

4.0 Principal Investigator(s)

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5.0 Authorized Negotiator(s)

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6.0 Past Relevant Performance Information

ReliOn currently has more than 110 fuel cell systems installed and operational in commercial applications covering 4 continents. Our fuel cell systems and backup power solutions have achieved numerous safety and performance certifications including; CSA, CE and NEBS Level III (telecom).

ReliOn's experience is inclusive of the following installations:

- **The Federal Aviation Administration;**
  - Palwaukee, IL, Radio Transmitter Receiver, December, 2003
  - Swinns Valley, WI, Microwave, June, 2004
  - Wakeman, OH, Microwave, August, 2004
  - Fargo, ND, RCAG, September, 2004

- Average turn-key cost was approximately $35,000
- Contacts: Mr. Stanley Lee, General Engineer, 847-294-8457;
  stanley.lee@faa.gov
  Mr. Steve Aldridge, Environmental Engineer, 952-997-9264;
  steve.aldridge@faa.gov

- **The Bureau of Reclamation;**
  - Loveland, CO, Microwave, October, 2003
  - System cost was approximately $15,000
  - Contact: Mr. Nathan Myers, Electrical Engineer, 303-445-2633
    nmyers@do.usbr.gov

- **The States of Maryland and Ohio;**
  - 2 Sites in MD, 4 Sites in OH
  - E-911 radio equipment, August 2003 to October, 2004
  - Average turn-key cost was approximately $30,000 (no outdoor enclosure)
  - Contact: Mr. George Milne, COO, havePOWER, 202-299-0506
    gmilne@havepower.com

7.0 Host Facility Information

Gabreski Air National Guard Base is the home of the 106th Rescue Wing. The 106th Rescue Wing, New York Air National Guard, is the parent organization of the Oldest Air National Guard unit in the Country—the 102nd Rescue Squadron. The 102nd Rescue Squadron traces its roots back to the 1st Aero Squadron which was formed in 1908 in New York.

The peacetime mission of the 106th Rescue Wing is two-fold. Firstly, it is tasked with conducting Search and Rescue (SAR) and Medevac Operations in an area delineated from the Northeast United States, south to the Bahama Islands and east to the Azores. The unit is able to provide long range rescue due to its air refueling capability. A rescue operation is illustrated in Figure 1. Secondly, the 106th Rescue Wing provides the Airborne Mission Commander (AIRBOSS) for every shuttle launch, as well as pararescuemen on board the HC-130 for deployment in the event of a Mode VIII event. Pararescue Jumpers are occasionally deployed to overseas locations during the launch to provide support to the Air Force. In addition to it's primary mission, the 106th RQW is tasked by the New Hampshire Fish and Wildlife Service with conducting extensive mountain search support.

The 106th is located in Westhampton Beach, Long Island, New York, which is approximately 80 miles east of New York City. The unit occupies one half of the Suffolk County airport named after Colonel Francis S. Gabreski, the leading living ace of World War II and Korea.

The project at Gabreski ANGB consists of a backup power solution for the base telephone PBX switch and peripheral equipment. The telecom equipment is located in the 106th Communications Squadron Headquarters, Building 250 as pictured in Figure 2. The site utilizes four (4) ReliOn I-1000 (1kW) fuel cells connected in parallel as a 4 kW source of backup power. The four fuel cell systems are housed in an outdoor enclosure installed just outside of Building 250. The fuel cell installation in the enclosure is shown in Figure 3.

Figure 1. 106th Rescue Wing Operation At Sea

Figure 2. 106th Rescue Wing Headquarters Gabreski ANGB

Figure 3. Fuel Cells Installed in ReliOn Outdoor Enclosure System at 106th Rescue Wing Headquarters Building

8.0 Fuel Cell Installation

The ReliOn Fuel Cell Outdoor Enclosure is a self-contained, turn-key system that is delivered to the site ready to set on the concrete pad and wire in to AC and DC circuits. System monitoring, data acquisition, and control are accomplished through Ethernet, analogue telephone (POTS), or discrete signal contacts, depending on configuration. The Scope of Work supplied by ReliOn to the general contractor for installation of the fuel cell systems at Gabreski ANGB including all power wiring and signal and control interconnection is given in Appendix 1. Installation drawings for the four fuel cell installation sites at Gabreski ANGB are included in Appendix 2.

The 4-kW fuel cell power system was installed adjacent to Building 250 at Gabreski ANGB. As part of this project, ReliOn specified and installed a new telecom uninterruptible power supply (UPS) system that functions in parallel with the Fuel Cell System. A schematic of the installation is shown in Figure 4.

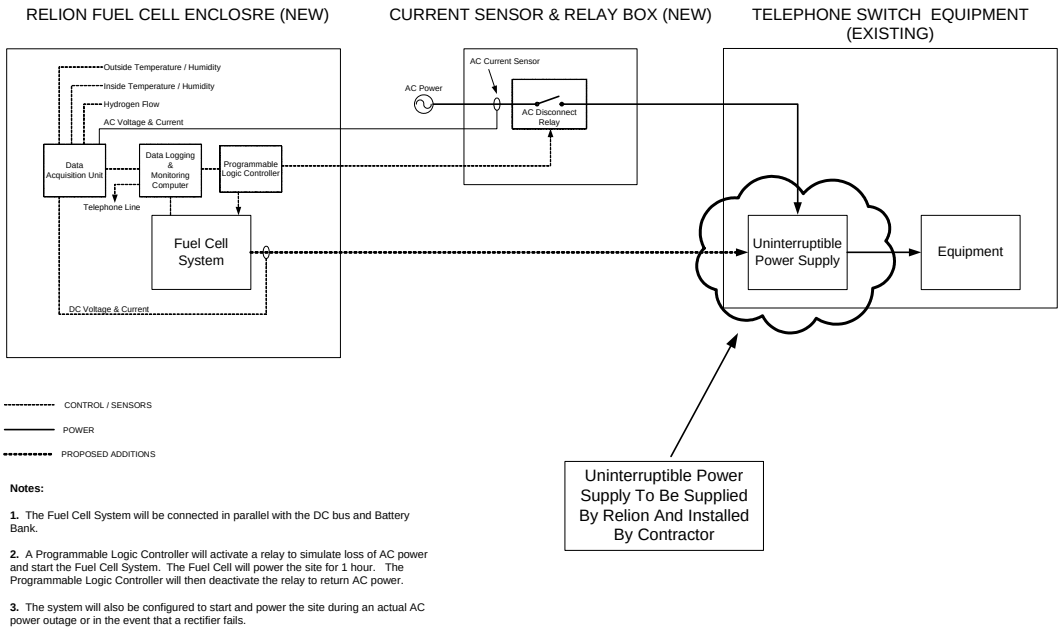

Figure 4. Fuel Cell / Uninterruptible Power Supply System

The fuel cells supply extended run power to the UPS system which in turn provides AC power to support telecom equipment installed at the customer's site. The telecom devices are listed in Table 1.

Table 1. Gabreski ANGB Telecom Equipment

Device	Voltage Rating (VAC)	Current Rating (Amp)	Load Rating (VA)
AT&T Definity MCC G3/SI Server	120	40	4800
Secure Logic ETM 3200 Modem	120	2.8	336
Data Smart 656 Analog Network CSU	120	2	240
CSI PA Amplifier	120	5.7	670
Total Equipment Load Rating:			**6046 VA**

When commercial AC power is available, the telecom equipment is supplied by the UPS through a 208 VAC rectifier. During an AC outage extended run time for the UPS system and telecom equipment is provided by the ReliOn fuel cell system which bypasses the rectifier. The ReliOn fuel cell supplies power at 48 VDC and is connected to the 48 V battery string on the UPS system.

The 4-kW fuel cell power system was installed at Gabreski ANGB in July 2004. The complete fuel cell enclosure system as installed is shown in Figure 5. The new UPS installation was completed on September 22. Base personnel requested a period of

preliminary testing before the telecom equipment was connected to the fuel cell. This initial testing was conducted between September 22 and December 9. During this time, the system accumulated 75 starts and 75 run hours. The equipment reliability and availability during this period were both 100%. The 1-year test program was started on December 10, 2004.

Figure 5. ReliOn Outdoor Enclosure System
At 106th Rescue Wing Headquarters, Building 250

The daily test runs are scheduled to occur during normal business hours over periods of representative equipment loads. This also allows ease of scheduling if host site personnel, ReliOn staff, and guests wish to observe the tests. The data from the laptop computer in the outdoor enclosure is downloaded to a server at ReliOn by remote dial-up after each system test run. The data logging computer also has an alarm notification utility that automatically dials preprogrammed phone numbers to notify ReliOn personnel of any alarm condition. One analogue POTS telephone line is used for remote monitoring at the site. The tests at Gabreski ANGB are timed as shown in Table 2.

Table 2. Gabreski ANGB CERL Test Schedule

Site No.	Site Name	Local Test Time (Eastern)
3-9	Gabreski Telecom Equipment	9:00 AM

The test run simulates a power outage everyday for a 60-minute time period in order to test the availability of the fuel cell system. A programmable logic controller (PLC) is installed with the system to simulate the grid outage by opening a relay to cut AC power to the UPS equipment. The PLC also monitors the run status of the fuel cells and will reconnect AC power to the UPS equipment should there be any type of operational failure that could jeopardize the protected equipment. The fuel cells are connected directly to the 48 Volt DC bus at UPS equipment rack. Once a day, AC power to the UPS equipment is disconnected. At the same time, the fuel cells start and provide power to the loads for 1 hour. At the end of the test period, AC power is restored and the fuel cells shut down.

In addition to the daily test, the fuel cell systems are configured to monitor the commercial AC power grid as well as the status of the UPS system batteries at the site. Upon loss or failure of either power source, the fuel cells will start automatically to provide up to 48 kWh of continuous run power to critical equipment at each site.

On-site maintenance is required when an alarm condition can not be corrected remotely. Routine inspections and maintenance visits are normally scheduled once per quarter. The ReliOn I-1000 fuel cell is a system based on removable cartridges that house the PEM membranes. If a membrane fails, the system continues to operate and there is a visual indication, as well as remote indication capability with the communications system. When it is convenient, the failed cartridge can be replaced. This task can be accomplished in less than one minute without the use of tools.

9.0 Electrical System

At the Gabreski ANGB telecom site, the fuel cell system runs in a grid-independent mode with the only interconnection being an AC sensing circuit in the fuel cell enclosure.

The fuel cell system is in a standby/ready mode to provide backup power for critical DC equipment when there is a loss of primary AC power. The following connections have been established at each site:

- Electrical Requirements:
  - One 20 Amp circuit at each site for AC sense and the enclosure heater. The heater is designed to keep the environment around the fuel cell above freezing to facilitate startup. Once the fuel is running, it utilizes its own heat for operation.
  - AC disconnect relay between AC power and rectifier
  - DC connection between fuel cell system and DC bus in customer's equipment cabinet
  - The PLC, data monitoring equipment, and data logging computer are powered from the 24 VDC terminals inside the enclosure. This ensures that the data continue to be recorded during an extended AC outage.
- Telephone Lines
  - One phone line required per site for data monitoring
  - One computer with dial-up capability at each site
  - See Appendix 2 for site specific connections

10.0 Thermal Recovery System

Because ReliOn's PEM fuel cells operate at low temperatures, the system is not a cogeneration system. The system is installed in an outdoor enclosure designed to maintain the internal temperature within the operating range of the I-1000.

11.0 Data Acquisition System

The telecom equipment load at Gabreski ANGB has been averaging between 1200 and 1500 watts. A Programmable Logic Controller (PLC) is used to start the fuel cell once a day for a test period of one hour. The PLC also energizes a relay at the same time to disconnect AC power from the rectifier in the UPS system.

A data acquisition system is also included in the enclosure to monitor and record the following:

- Inside temperature
- Inside Humidity
- Outside Temperature
- Outside Humidity
- AC Voltage at the site
- AC current at the shelter rectifier
- DC Voltage at the shelter DC bus
- DC current from the fuel cell
- Hydrogen fuel flow

All vital information from the I-1000 fuel cell is also monitored and recorded. The data-logging computer is connected to the data acquisition module and fuel cell via Ethernet. The data-logging computer is configured to dial a designated ReliOn personnel cell phone during any of the following alarm conditions:

- Loss of AC Voltage
- Low DC Voltage (Less than 50 VDC)
- Hydrogen Sensor Alarm
- Fuel Cell Major Alarm
- Hydrogen Bank Empty
- Enclosure Fan Alarm

The system is also configured to start automatically during a loss of the AC grid and in the event the facility DC bus voltage falls below a pre-determined limit (low voltage startup). The low voltage startup protects the telecom equipment in case of a facility rectifier/charger failure or a fault in the battery string. The low voltage start threshold has been set at 50 VDC for the installation at Gabreski ANGB.

Daily run data for each site is available at ReliOn's customer data website at http://www.relion-inc.com/customers/cerl3/. Contact ReliOn's CERL Project Principal Investigator for login name and password. Monthly run data summaries through January 2005 are included in Appendix 3.

12.0 Fuel Supply System

The fuel cell systems operate with industrial grade hydrogen gas. Compressed gas is the easiest and most commercially available source of industrial grade hydrogen. The outdoor enclosure includes two locked hydrogen storage and delivery systems which ensure that the compressed hydrogen cylinders are protected and accessible only to authorized personnel. A sketch of the hydrogen compartments is shown in Figure 6.

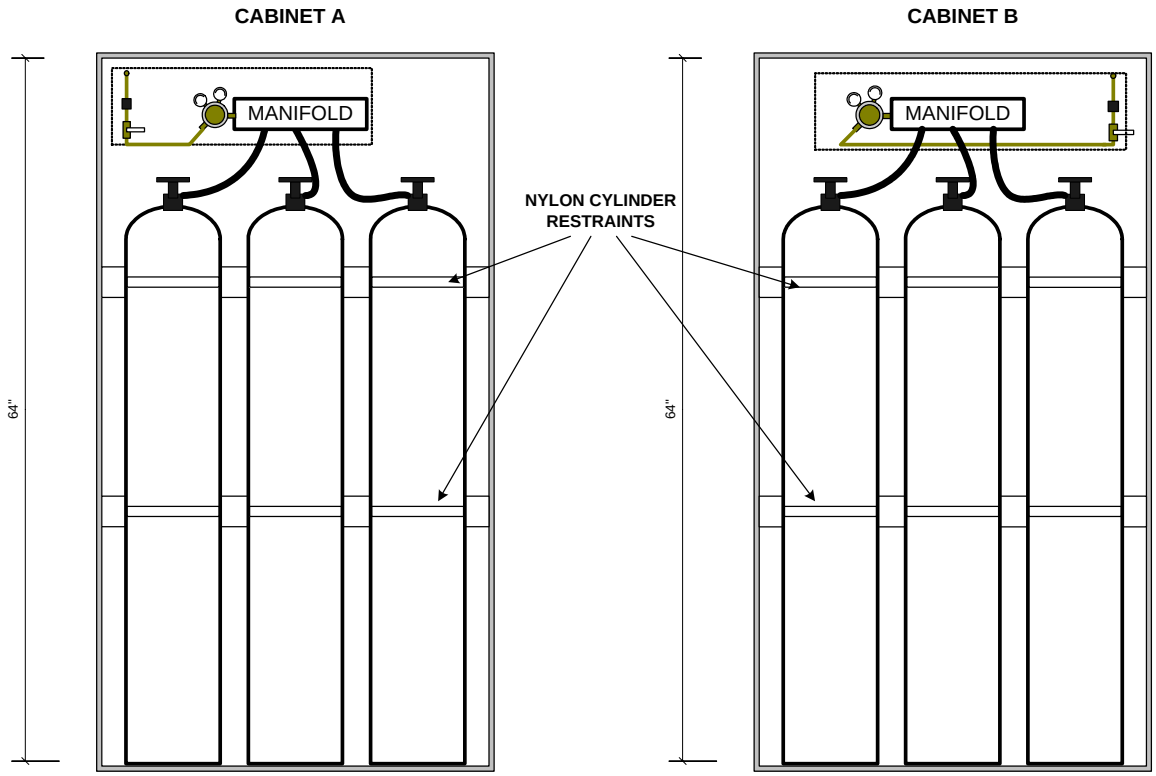

Figure 6. Hydrogen Fuel Compartments

The cylinders are typically size 300 (nominal 285 cu. ft or 8071 liter gas capacity at STP conditions), although size 200 can also be accommodated. Full cylinders are delivered with gas pressure at between 2000 and 2200 psig. Each of two hydrogen storage compartments contains three (3) cylinders directly connected into a high pressure manifold. The manifolds are each equipped with pressure switches and a regulator to reduce the gas pressure for delivery to the fuel cell. The pressure switches are monitored by the data logging computer which will send an alarm to the ReliOn personnel when the gas pressure falls to a pre-determined level. Hydrogen gas deliveries are made to each site by the local distributor for Airgas, Inc. at approximately 3 week intervals. Additional deliveries are made as required in the event of an extended AC grid outage or if extra testing is conducted.

The optimal setting for the pressure regulators to the fuel cell is 40-50 psig. By adjusting the regulated pressures so that one bay is 5-10 psig higher than the other side, hydrogen will flow out of the higher side only until those cylinders are exhausted. The system will then draw hydrogen from the other side allowing time to order and replace the depleted cylinders.

The fuel supply system and refill logistics have worked well so far in the project. There was however a fuel outage over the Christmas & New Years holiday (between December 29 and January 5), during which the fuel cells did not start. This resulted in an overall loss of 8 starts and 8 hours of run time in December and January. During the balance of

the testing, the equipment reliability and availability have been 100%. Closer site monitoring and improved fuel delivery scheduling has prevented further fuel outages.

13.0 Installation Costs

Table 3 shows a breakdown of project costs thru January 2005 for the ReliOn PEM fuel cell backup power demonstration project at Gabreski ANGB. The total project proposed cost including ReliOn's profit and cost share for the entire contract was $363,781.64. Of this amount, $100,284 was allocated for the Gabreski ANGB site. Total expenditures charged to CERL through January 2005 for the Gabreski ANGB are $86,256.

Table 3. Project Costs for Contract Number W9132T-04-C-0017 (Gabreski Site)

Task 1: Fuel Cell Power Plant **Direct Labor**		Plan			Actual Through January 2005
Staff	Activity	Units	Unit Cost	Total Cost	
Applications Engineer	Training			$300	$300
Equipment					
I-1000 Fuel Cell		4	$8,050	$32,200	$32,200
Enclosure w/2 Fuel Wings		1	$5,950	$5,950	$5,950
Extended Rack for Hydrogen Delivery System		1	$2,500	$2,500	$2,500
Telecom UPS Systenm\\m		1	$3,800	$3,800	$3,800
Task 1 Subtotal Budget				**$44,750**	**$44,750**

Task 2: Installation **General/Electrical Contractor**	Plan			Actual Through January 2005
General Contractor			$1,600	$1,600
Electrical Contractor			$4,800	$4,800
Materials & Expenses				
Crane/Fork Lift			$1,000	$1,000
Telecommunications			$2,600	$2,600
Task 2 Subtotal Budget			**$10,000**	**$10,000**

Task 3: Performance Monitoring **Direct Labor**		Plan			Actual Through January 2005
Staff	Activity	Units	Unit Cost	Total Cost	
Applications Engineer	Monitoring & Data Management			$2,600	$1,250
Principal Investigator	Monitoring & Data Management			$1,200	$800
Task 3 Subtotal Budget				**$3,800**	**$2,050**

Task 4: Maintenance **Direct Labor**		Plan			Actual Through January 2005
Staff	Activity	Units	Unit Cost	Total Cost	
Applications Engineer	On Site Training			$300	$300
Applications Engineer	Remote & Site Maintenance			$800	$300
Principal Investigator	Remote & Site Maintenance			$0	$200
Task 4 Subtotal Budget				**$1,100**	**$800**

Task 5: Project Management & Reporting **Direct Labor**		Plan			Actual Through January 2005
Staff	Activity	Units	Unit Cost	Total Cost	
Project Manager	Management, Reporting, Meetings			$1,200	$1,400
Principal Investigator	Management, Reporting, Meetings			$800	$500
	Initial Project Description			$600	$600
	Monthly Status Report			$300	$200
	Midpoint Report			$600	$600
	Final Report			$600	$0

Table 3 (Continued).
Project Costs for Contract Number W9132T-04-C-0017 (Gabreski Site)

Task 6: Travel			Plan		Actual Through January 2005
Managerial Travel				$1,685	$1,685
Technical Travel-Installation				$2,312	$2,312
Technical Travel-Maintenance				$9,556	$9,200
Technical Travel-Decommissioning				$1,894	$0
Task 6 Subtotal Budget				**$15,447**	**$13,197**

Task 7: Decommissioning/Site Restoration			Plan		Actual Through January 2005
Direct Labor					
Staff	Activity	Units	Unit Cost	Total Cost	
Applications Engineer	Site Work			$0	$0
Principal Investigator	Site Work			$0	$0
General/Electrical Contractor					
Labor				$3,200	$0
Materials & Expenses					
				$2,000	$0
Task 7 Subtotal Budget				**$5,200**	**$0**

Task 8: Other Costs		Plan		Actual Through January 2005
Equipment & Expenses				
Hydrogen Fuel			$9,400	$7,850
Electrical Equipment			$7,500	$7,500
Task 8 Subtotal Budget			**$16,900**	**$15,350**

Gabreski Total Budget	**$101,297**	**$89,447**
Profit (10%)	$10,130	$8,945
Gabreski Total Project Cost	**$111,427**	**$98,392**
ReliOn Cost Share (10%)	($11,143)	($12,136)
Gabreski Total Project Billing	**$100,284**	**$86,256**

14.0 Acceptance Test

Commissioning procedures involve manual system start-ups and shut-downs, verification of loss of AC auto starts, verification of low battery voltage auto starts, and verification of system alarm functionality. ReliOn commissioning instructions for commercial installations of the I-1000/Outdoor Fuel Cell System are given in Appendix 4. Test and demonstration installations that include PLC controllers, data monitoring and recording equipment, computer logging, and remote data communication are subject to further commissioning procedures to verify functionality, data logging, and communication processes.

The final part of the acceptance test at each site is the measurement of voltage stability while providing power to the equipment under normal load conditions. Results of these tests at Gabreski ANGB are shown in Figure 7. As indicated, the maximum measured voltage variation of each fuel cell system was well less than the product engineering specification of < 1.0 VDC peak to peak at 100 kHz.

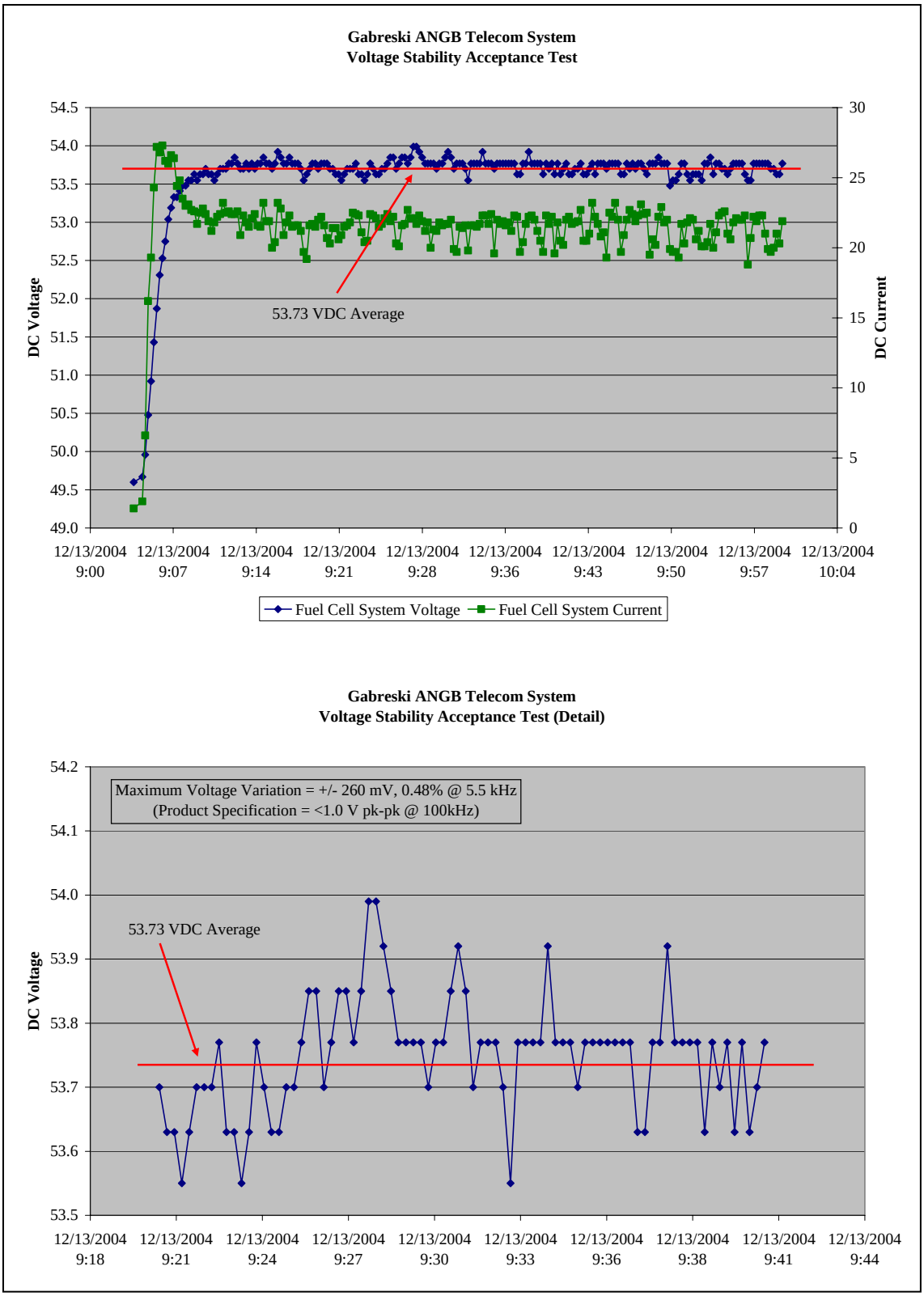

Figure 7. Gabreski Telecom System
Fuel Cell Voltage Stability Test

Appendix

1) ReliOn Fuel Cell System Site Preparation Contractor Scope of Work
2) Gabreski ANGB Fuel Cell Installation Drawings
3) Monthly Performance Data
4) Commissioning Procedures for the I-1000™ Fuel Cell & Outdoor Enclosure System